

An aerial photograph of the Jefferson Lab facility, showing various buildings, parking lots, and surrounding greenery. The text is overlaid on the image.

Remote SRF Operation

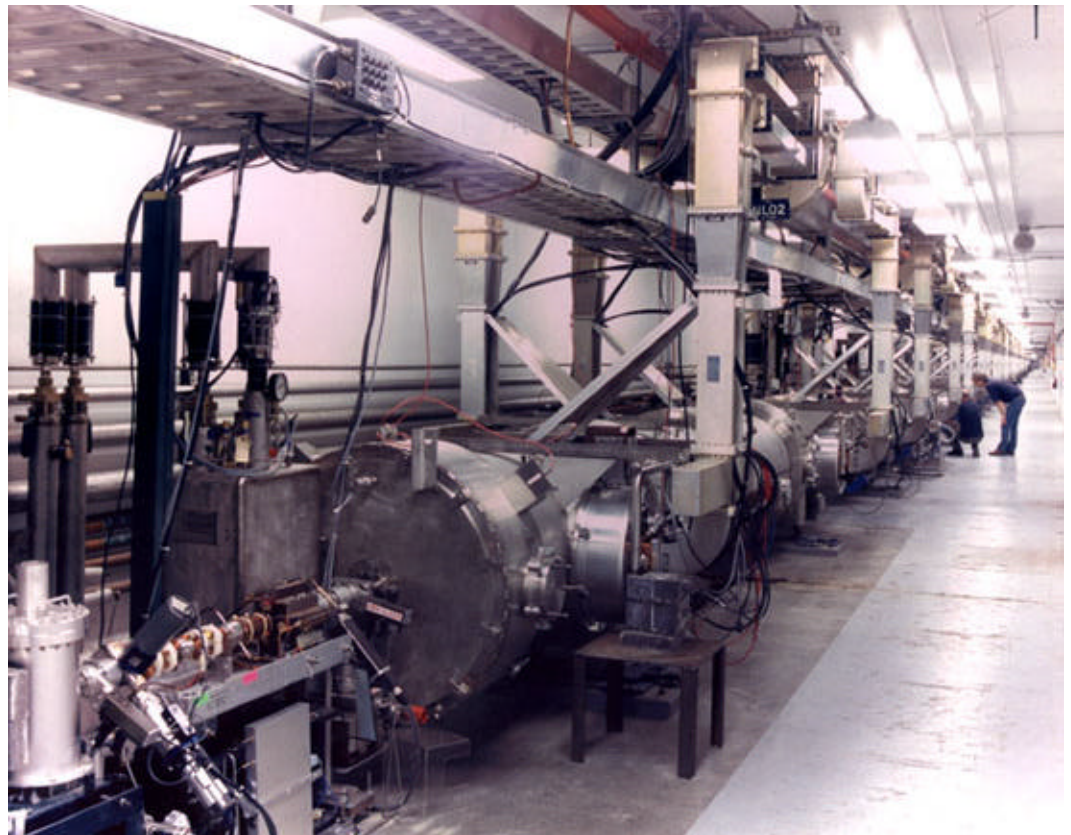
Andrew Hutton

Director of Operations

Jefferson Lab

Outline

- Motivation
- SRF reliability data from 4 years of CEBAF operations
- Indirect availability impact
- Remarks on remote operation



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Motivation

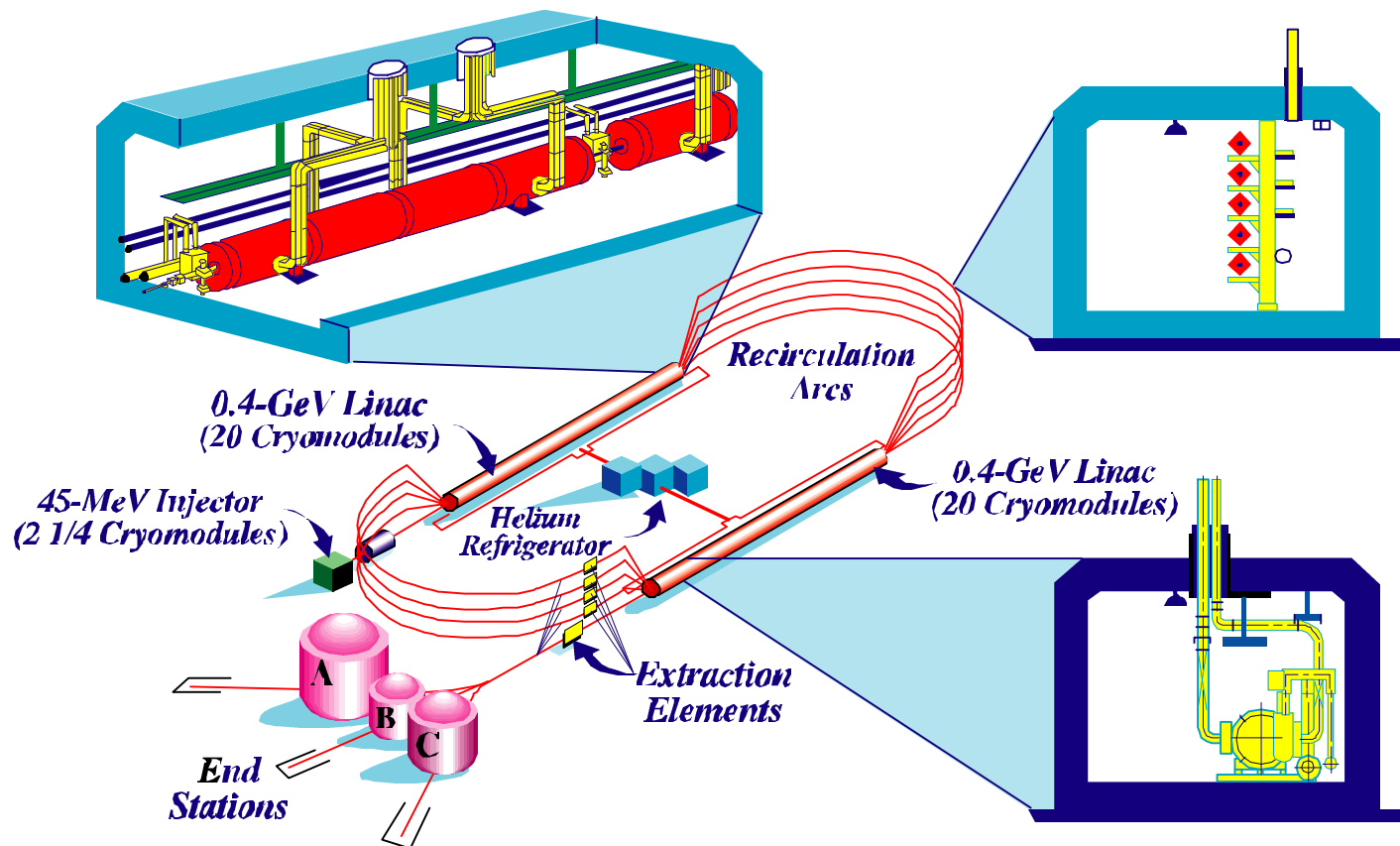
- This talk will address the question:

What would it mean to operate superconducting systems remotely?

- Operational experience from CEBAF will be presented to demonstrate that SRF is extremely reliable, but auxiliary systems must be considered and are more important



MACHINE CONFIGURATION



Downloaded from www.jlab.org



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CEBAF SRF Cavities



CEBAF 5-cell cavities operate at 1497 MHz with an active length of 50 cm each

There are eight cavities per cryomodule



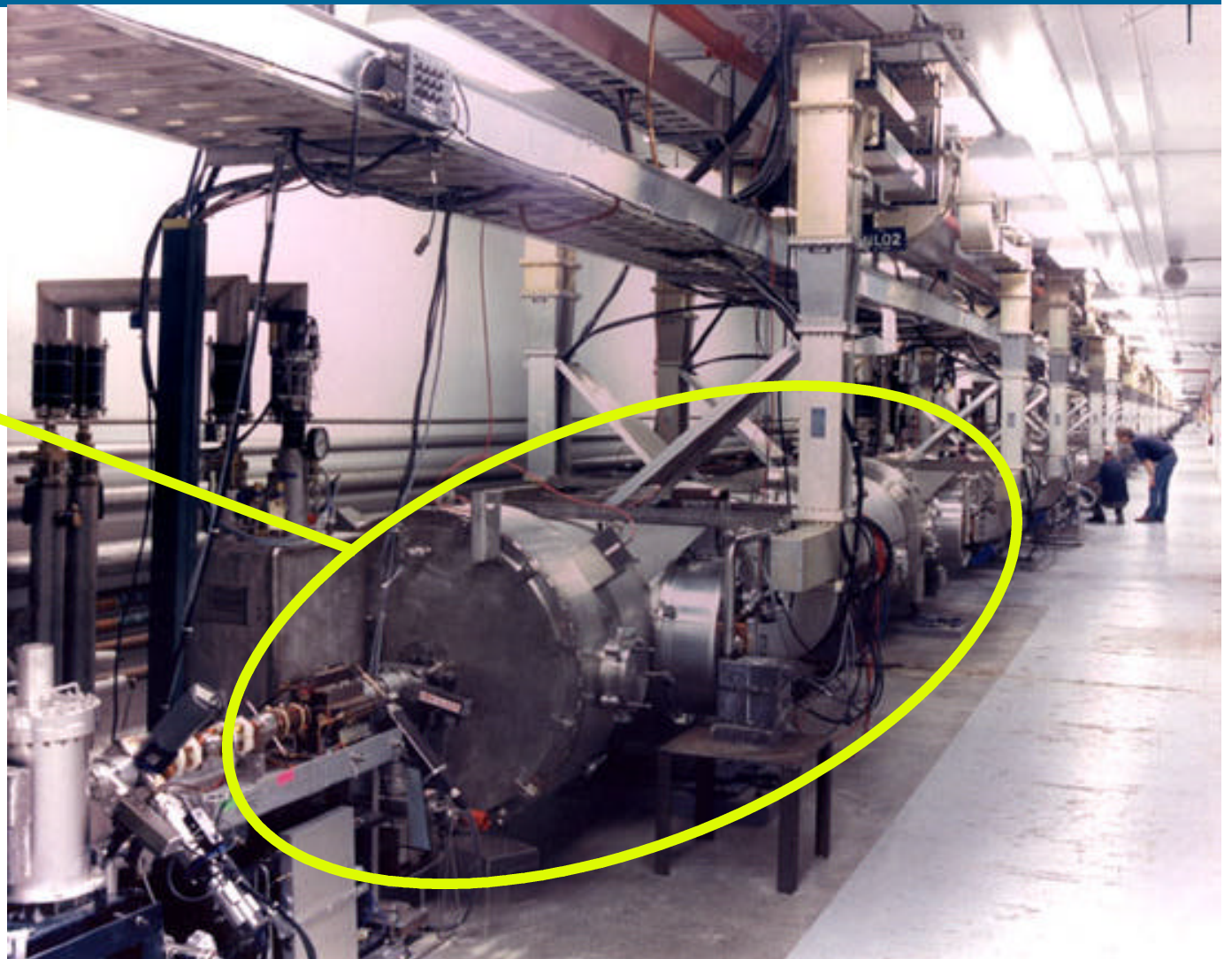
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Linac Cryomodules

CEBAF has 42¼
cryomodules
with a total
active length of
169 meters



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Availability Tracking

- Downtime is tracked daily and assigned to a system
 - Simultaneous failures are all counted
 - no lucky breaks!
- Downtime totaled every month, plotted in decreasing order of total downtime over the last six months
 - Most recent month on the bottom
- Assign resources to the worst offenders



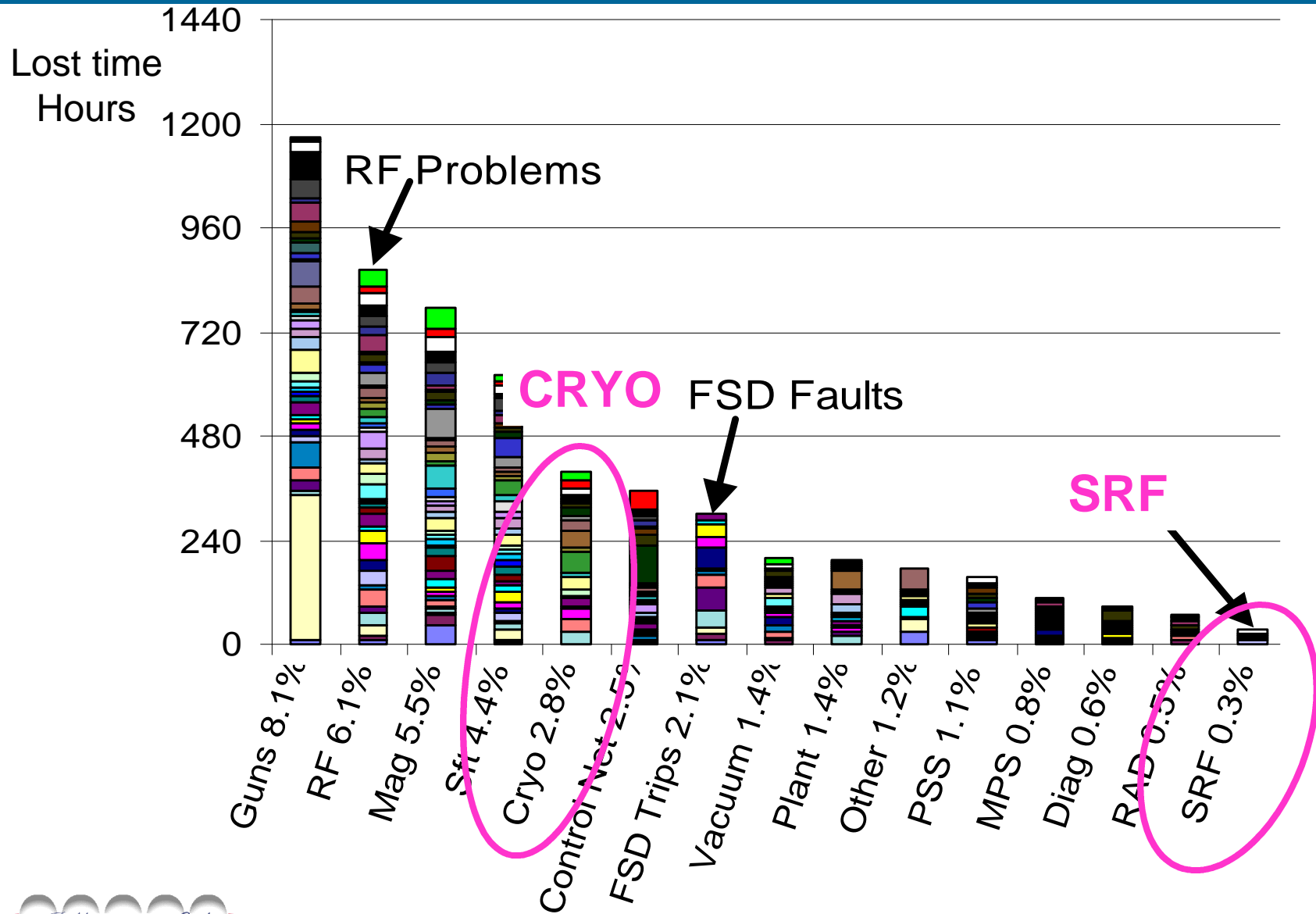
Four Year Downtime Totals

- Reliability data has been tracked since June 97
 - All available on spreadsheets for trend analysis
- For this talk, the data for the last four years has been integrated into one plot

SRF is the system with the smallest
amount of lost time



CEBAF Lost Time Totals June'97-May'01



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Associated Hardware

This is not the whole story!

- Other systems are designed to support SRF cavities
 - More “delicate” than for copper RF systems
- Must have a cryogenics plant
 - Extremely difficult to maintain remotely
 - Requires constant electro-mechanical maintenance

Must consider total package when assessing overall impact on reliability



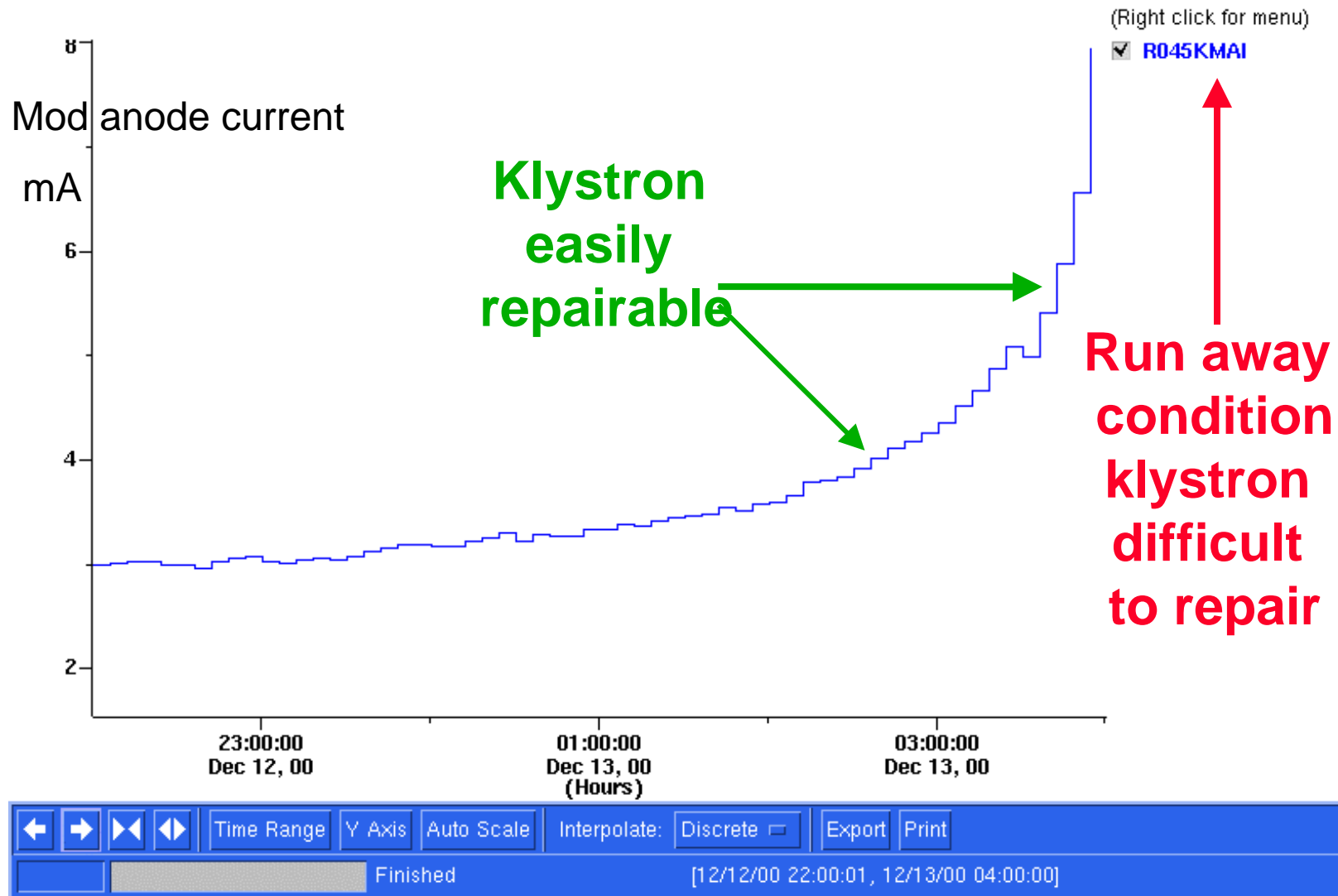
RF Systems

KLYSTRONS:

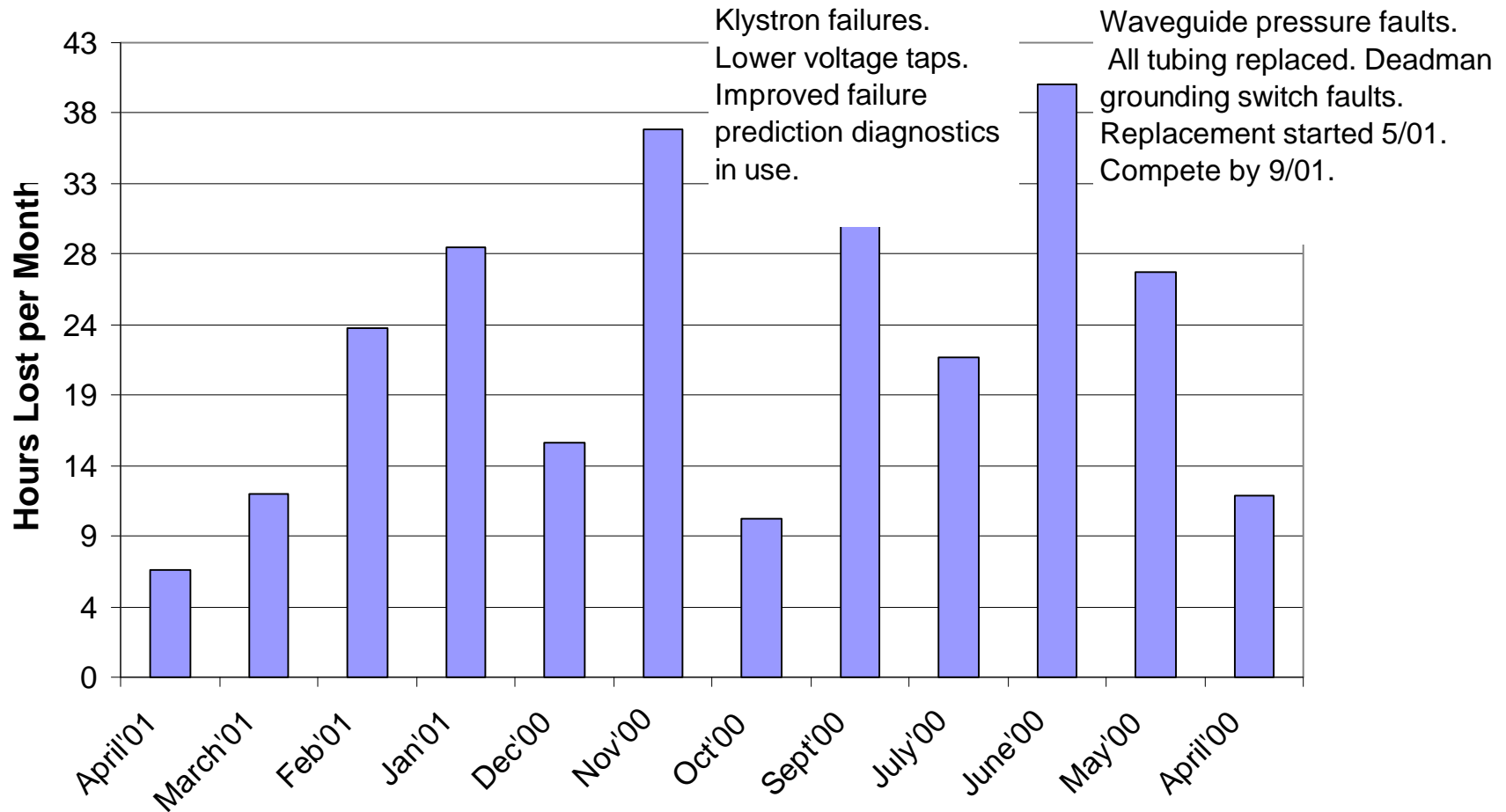
- One per cavity to provide phase and amplitude control to ensure low energy spread
- Klystrons (338 of them) have ~50,000 hours each
 - Manufacturer guaranteed 20,000 hours
- Starting to see excessive mod anode current which causes overheating
 - Most klystrons can be repaired if caught in time



JLab ELog Entry of a Klystron Alarm



RF Lost Time

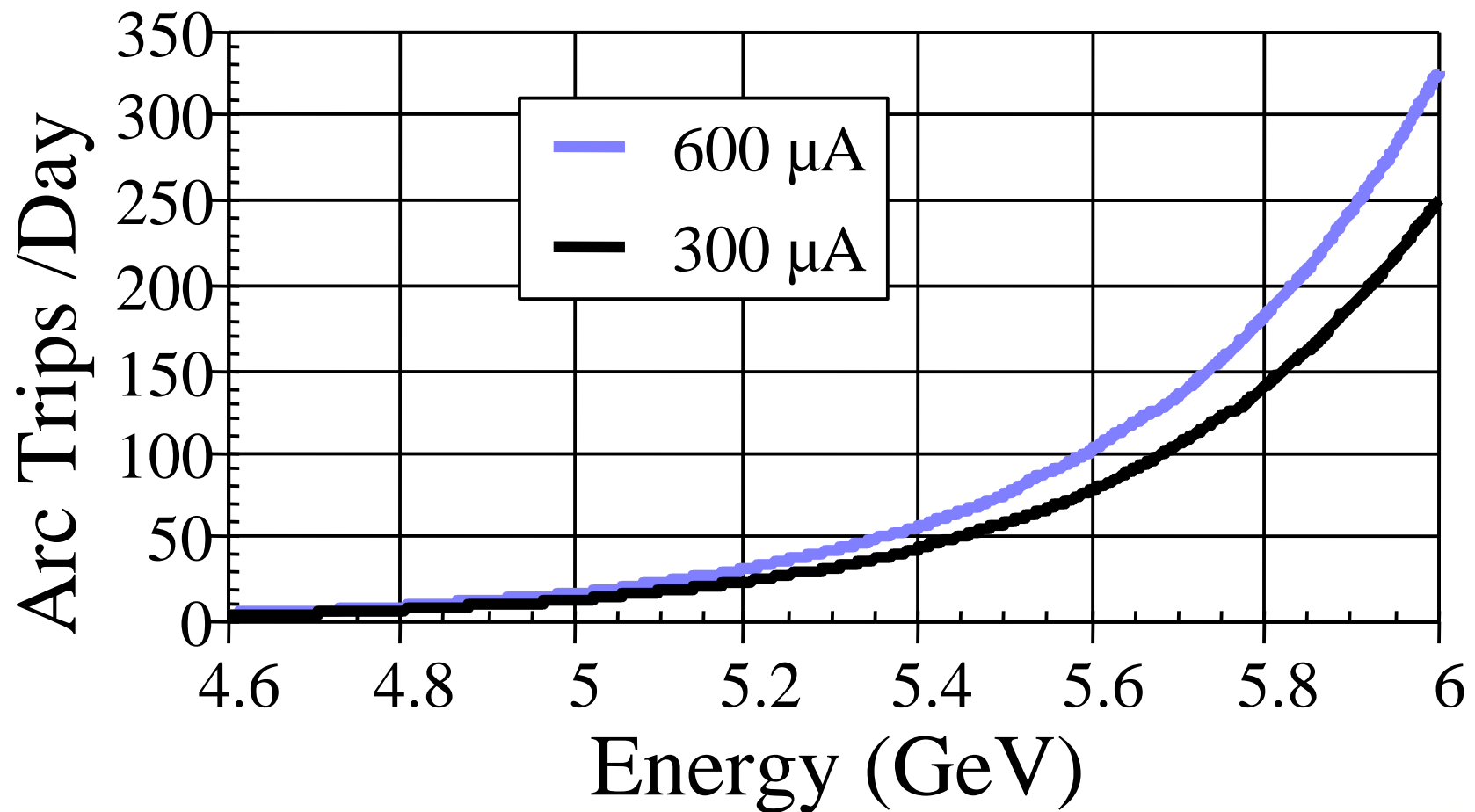


FSD Trips

- Fast Shut Down (FSD) trips are triggered by RF arcs and protect the SRF cavities from arc damage
 - ¿Caused by charging up of ceramic widows?
 - ¿Caused by “three dimensional” gas discharges?
- Strongly dependent on accelerating gradient
 - Weakly dependent on total linac beam current

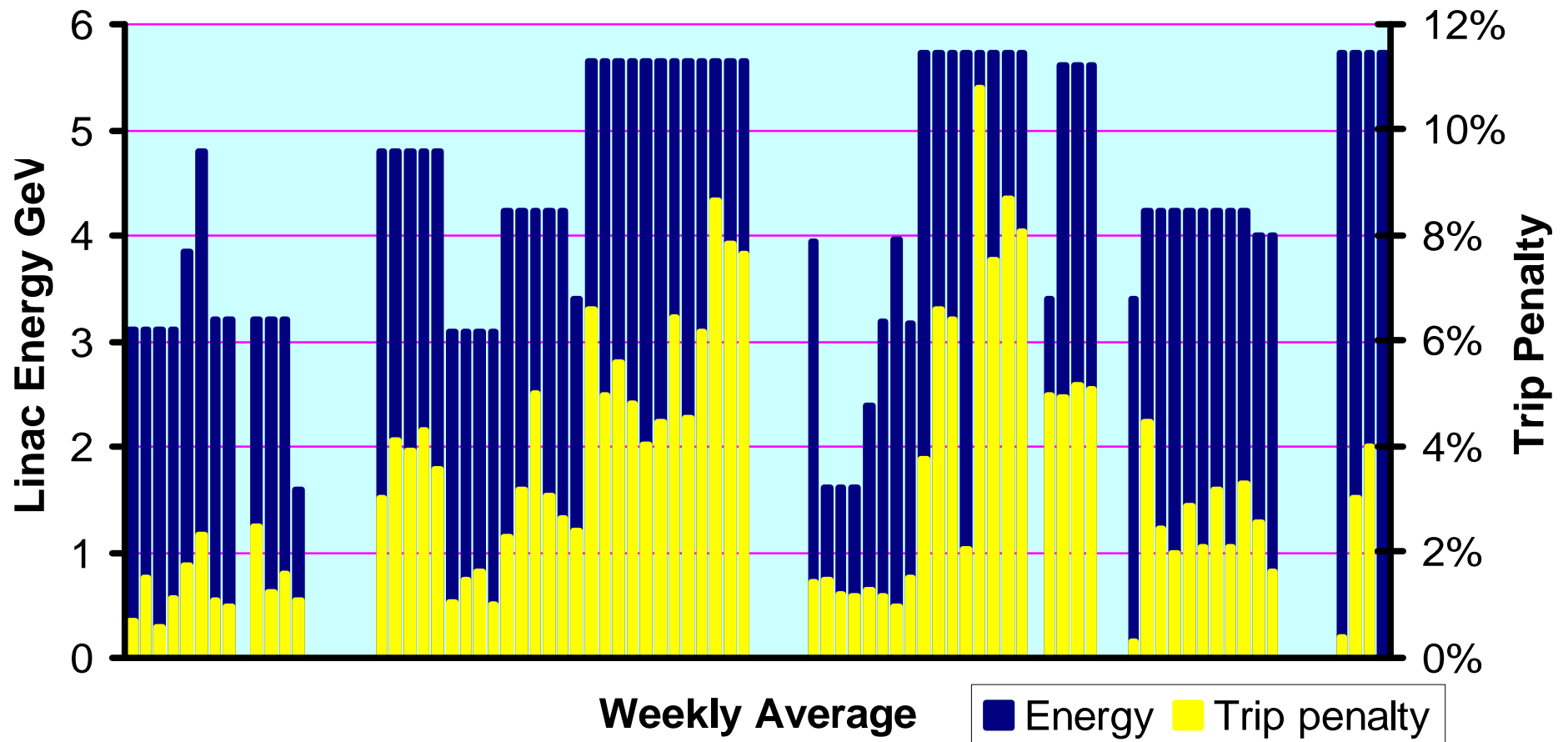


Arc Trips Per Day vs. Energy



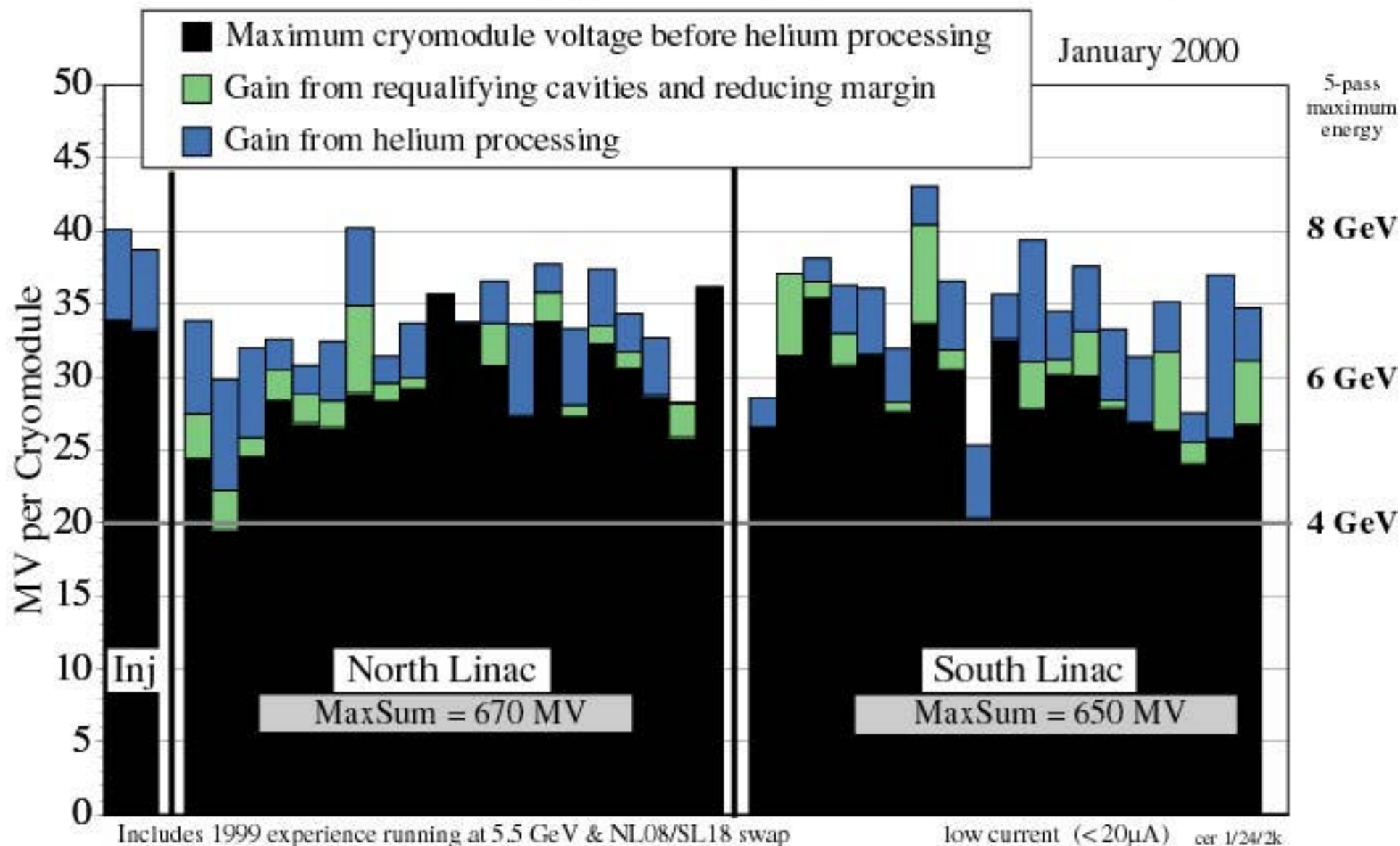
FSD Trip Rate Versus Energy

October 99 – June 01



Maximum SRF Cavity Voltage per Cryomodule in CEBAF

(Eight 0.5 meter, 1497 MHz srf cavities per cryomodule)



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Hardware

- Superconducting RF cavities operating in a stable, cryogenic environment are extremely reliable
 - No water cooling
- Other systems may be more complex (less reliable) to support SRF cavities
 - RF power sources more distributed
 - RF control more elaborate
 - Protection devices may add downtime
 - Must have a cryogenics plant



Remote Operation

- SRF Cavities need little oversight
 - New cavity designs should reduce or eliminate RF trips
 - Restoring cavities can be automated
 - Protection systems must be automated
- RF systems are more complex – single klystron per cavity often required for flexibility
 - Means that systems can be taken offline and beam delivery continued
- Operation of large number of RF systems needs a lot of operator intervention



RF Optimization

- Large number of automated routines needed to:
 - Switch on systems
 - Tune cavities
 - Establish desired energy profile
 - Phase cavities
 - Maintain gradient and phase under changes in operational conditions
- All of these routines can be supplied to an operations crew which can be local or remote
 - No difference



Remote Limitations

- “Problem systems” – may need local intervention
- All other parameters are already under control
 - Would not need an enormous effort for remote operation of SRF cavities and associated software routines
 - They are needed anyway
- Initial debugging of broken hardware can be done remotely
- “Problem systems” can be taken offline
 - Present operational practice



Conclusion

- SRF Cavities and associated controls are good candidates for remote operation
 - Complex systems require massive software oversight now
 - Few additional problems for remote operation
- SRF cavities *per se* do not need a lot of oversight
- Most problems will be with the power sources
 - Similar to conventional magnet systems – most maintenance problems are with the associated power supplies

